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# Evaluating Educational Inputs in Undergraduate Education

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# EVALUATING EDUCATIONAL INPUTS

# IN

# UNDERGRADUATE EDUCATION

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# EVALUATING EDUCATIONAL INPUTS IN UNDERGRADUATE EDUCATION

This paper examines the input-output relationship for private undergraduate education. The motivation for such a study stems from a long-standing concern within academe for a better understanding of the relationships between student quality, faculty effort, campus environment, and the end result of an "educated" person. Though precise and objective measures of educational output are difficult to formulate, we would argue that alumni achievement is an important and measurable output.[1] Specifically, we focus on the number of baccalaureate alumni who went on to earn a Ph.D.[2] But even with an acceptable output measure, research assessments of the educational process are not dealing with a production function in the classical supply-and-demand sense. For example, the purchaser of the product - the student - is also among the more important factor inputs. The implication is that the educational process is far more complicated than a simple, production-function rendering indicates.[3] Consequently, this study formulates a three-equation simultaneous model of student quality, faculty quality, and output. The study's objective is to identify the relative contribution of the many human and nonhuman resources commonly regarded as producing quality undergraduate education.

Section I defines the focus of our study and its relevance to the substantial existing literature. Section II describes the model and discusses the estimation procedure. Section III presents the empirical results. The study's conclusions appear in Section IV.

## I. The Literature

A vast and diverse literature exists on the economics of education; thus, it is expedient to emphasize at the outset the aspects of this study which define its focus.[4] Generally, much of the research into the economics of education has pursued either of two tacks. The first emphasizes a human capital perspective examining the financial return to the quantity and quality of higher educational investment [Becker (1962-64); Hunt (1963); Weisbroad & Karpoff (1968); Hause (1972); Solman (1973)]. The second emphasizes the educational production process [Astin (1968); Bowles (1970); Summers & Wolfe (1977); McGuckin & Winkler (1979)] relating differences in educational achievement to economic and noneconomic factors through a production function specification. Our study falls generally within the latter research category, though notable features distinguish it.

First, production across baccalaureate institutions is measured in terms of the number of alumni who have received Ph.D.'s. Measurement in this manner has an important implication. Typically, income or achievement test scores have been used as a proxy for educational output. Since these types of output observations are specific to individuals and not institutions, prior studies have tended to identify factors that affect individual achievement within a single school system or college, rather than factors that may explain differences in output across colleges. In this study, we shift the focus to differences in institutional output instead of individual achievement.

The model developed in this paper is also notable for its simultaneous system approach. This specification, not previously employed to our knowledge, captures the character of simultaneity in the educational production process. The production relationship for higher education typically expresses output (e.g., income or GRE scores) as a function of university resources (e.g., faculty, capital plant, endowment) and student characteristics (e.g., SAT scores, family background data). In functional form:

$$Q = f(R,S) \tag{1}$$

where Q, R, and S denote output, resources, and student characteristics. Straightforward as this expression may appear, it masks an interdependence among inputs that may be the hallmark of higher education. We argue that faculty are drawn to schools where able students combine with strong financial and physical resources to produce an exciting and productive academic environment. The reputation of the school, in turn, promotes the acquisition of these resources. Further, student and faculty inputs themselves may influence the allocation of university resources over time. In order to address this interdependence, the relationship expressed in equation (1) is more appropriately specified by a three-equation simultaneous model in which the quality of college output, faculty, and students are treated endogenously. Such a simultaneous system approach is largely the focus and contribution of this study.

## II. The Model

The model builds on the premise that quality students and faculty interacting in a conducive campus environment nurtures the intellectual growth and spirit that motivates a student to pursue a doctoral degree. An interesting aspect of this production relationship is that two of the more important factors, students and faculty, enter the process upon considerable self-selection, especially among the more highly qualified of these inputs. A model of higher educational production must reflect the broader perspective that the quality of output can influence the quality of inputs, and that certain institutional resources may themselves enhance the quality of other inputs that the school attracts. Toward this end, our model expands the typical single-equation specification in order to consider the significance of self-selection on the part of student and faculty inputs. Thus we arrive at a three-equation system of the following general form:

(2) $$\beta y_i + \Gamma x_i = u_i$$

where $y_i$ = a vector of three endogenous variables for school output (Q), faculty quality (F), and student quality (S).

$x_i$ = a vector of fourteen exogenous variables representing a school's tuition (T); endowment (E); capital stock (K); faculty-ratio (FSR); undergraduate specialization ratio (USR); student gender ratio (SEX); support expenditures for administration (AD); research (RE) and academic activities (AC); student loan (L) and scholarship (SCH) funds; and three regional binary variables contrasting north Atlantic (NA), great lakes (GL), and western (W) states with the southeast.

$\beta$ = 3x3 matrix of endogenous variable coefficients

$\Gamma$ = 3x14 matrix of exogenous variable coefficients

$u_i$ = a vector of three error terms assumed to be distributed normally with zero mean and constant variance. Errors are assumed to be uncorrelated across equations.

i = observation index for 173 private, undergraduate-oriented universities.

Implicitly the model is written:

(2) $Q = f_1$ (S, F, K, AC, AD, FSR, USR, SEX, u)

(3) $S = f_2$ (Q, F, K, T, SCH, L, FSR, USR, SEX, u)

(4) $F = f_3$ (S, K, E, RE, AC, USR, FSR, NA, GL, W, u);

where Q = the number of alumni Ph.D. recipients,

S = median SAT score of entering class,

F = faculty salary.

In order to adjust for differences in institutional size, most observations are expressed in per student-capita terms. The exceptions are faculty salaries and research (per faculty-capita) and the regional binary variables. Details on the listed variables appear in Table 1. The general rationale behind the equations is considered below.

Equation (2) posits that successful Ph.D. candidates are the product of quality human (SAT, SAL & AD) and nonhuman (K, AC) resources. Also, the nature (USR) and intensity (FSR) of the human element is deemed important in stirring scholarly ambitions. A school's percentage of male students (SEX) is included to adjust for the fact that the Ph.D. degree was male-dominated over the bulk of our time period. The predicted signs of the coefficients of equation (2) are all positive.

Equation (3) suggests that quality students are drawn by a school's reputation as reflected in alumni achievement (Ph.D.), quality faculty (SAL), the physical plant (K), provision of scholarships and loans (SCH & L), and factors indicating emphasis on the student (USR & FSR). Again, the predicted signs are all positive. A high price (tuition or T) should be a deterrent to all students for an equal-quality product. However, if price reflects quality and if our other measures do not adequately account for such quality differences, then we could expect a positive influence of T on student quality. The proportion of male students (SEX) is included merely as a control for the possibility that males who go on to college have different SAT characteristics than do females. We offer no prediction regarding this variable.

Equation (4) can be viewed as a reduced-form equation of a supply-and-demand system for faculty quality. On the supply side, quality faculty prefer schools with good students (SAT), ceteris paribus. On the institutional demand side, two variables are included to control for salary differentials unrelated to faculty quality. Colleges with low undergraduate specialization ratios (USR) are predicted to have higher average salaries because of the higher salaries paid to graduate professors, especially law professors. Further, we anticipate salaries to be higher in the North Atlantic (NA), Western (W), and Great Lakes (GL) region vis-a-vis the Southeast because of cost-of-living differences. The remaining variables affect both supply and demand. The size of an institution's endowment (E) represents financial security to faculty and ability-to-pay to institutions, both positive influences. Other variables have offsetting influences resulting in ambiguous expectations for the reduced-form coefficients. While faculty might prefer better physical facilities (K) and higher academic expenditures (AC), institutions might view them as substitutes for faculty. And while faculty might prefer higher research support (RE) and smaller classes (FSR), administration might view these as income-in-kind.

## III. Estimation Procedure and Empirical Results

We estimated the linear form[5] of our model through a three-stage least squares (3SLS) procedure. A three-stage procedure was employed in

Table 1

Variables Within the Model

| Variable (X) | Mean & Std. Dev. | Max Min | $\frac{\partial Q}{\partial X}$ | $\frac{\partial S}{\partial X}$ | $\frac{\partial F}{\partial X}$ | Definition and Comment |
|---|---|---|---|---|---|---|
| Output (Q) | 23.04<br>17.08 | 108.20<br>3.12 | | + | | Number of alumni Ph.D. recipients from 1920-1976 per 100 1981 undergraduate equivalent students.[a,c] |
| Students (S) | 1041.2<br>109.6 | 1310.0<br>730.0 | + | | + | Median composite SAT score of 1981 freshmen class.[c] |
| Faculty (F) | 23.40<br>2.60 | 28.6<br>15.8 | + | + | | Mean faculty salary of associate professors for 1981 in $1,000.[d] |
| Tuition (T) | 4.79<br>1.18 | 7.35<br>0.11 | | − | | 1981 tuition in $1,000.[c] |
| Endowment (E) | 24.15<br>19.52 | 116.12<br>3.84 | | | + | 1981 endowment per student-capita in $1,000.[e] |
| Capital (K) | 14.55<br>6.19 | 35.43<br>4.12 | + | + | + | 1981 book value of the capital stock per student-capita in $1,000.[e] |
| Academic (AC) | .48<br>.29 | 1.84<br>.11 | + | | + | 1981 academic support outlays per student-capita in $1,000. Generally, a substantial part of this value reflects library expenditures.[e] |
| Research (RE) | 2.43<br>6.08 | 52.05<br>0.00 | | | + | 1981 research support outlays per faculty-capita in $1,000.[e] |
| Administration (AD) | 1.59<br>.58 | 3.67<br>.14 | + | | | 1981 administration support outlays per student-capita in $1,000.[e] |
| Scholarship (SCH) | .80<br>.40 | 2.33<br>.22 | | + | | 1981 scholarship funds per student-capita in $1,000.[e] |
| Loans (L) | 1.11<br>.58 | 3.26<br>0.00 | | | | 1981 student loan funds per student-capita in $1,000.[e] |
| Faculty/Student Ratio (FSR) | 5.7<br>1.5 | 11.9<br>2.7 | + | + | + | Faculty per 100 full-time undergraduate equivalents.[c] |
| Undergraduate Specialization Ratio (USR) | 89.6<br>12.9 | 100.0<br>35.7 | + | + | ? | Undergraduate specialization ratio calculated as the number of actual full-time undergraduates per 100 full-time undergraduate equivalents.[c] |
| Sex Ratio (SEX) | 50.7<br>15.2 | 100.0<br>0.0 | + | ? | | Male population per 100 of undergraduate equivalent population.[c] |
| North Atlantic (NA) | .36<br>.48 | 1.0<br>0.0 | | | + | Binary variables for the North Atlantic, Great Lakes, and Western regions, respectively. These binaries are included to control for salary differentials that could be attributable to regional cost-of-living difference. |
| Great Lakes (GL) | .35<br>.48 | 1.0<br>0.0 | | | + | |
| Western (W) | .15<br>.35 | 1.0<br>0.0 | | | + | |

a Undergraduate equivalent population reflects the conversion of full and part-time undergraduate and graduate students to a full-time undergraduate student equivalent (FUE). These sub-populations are weighted according to the following algorithm:

$$FUE = [(\#FU \times 1) + (\#PU \times .25) + (\#FG \times 1.25) + (\#PG \times .5)]$$

where #FU is number of full-time undergraduates, #PU is number of part-time undergraduates, #FG is number of full-time graduates, and #PG is number of part-time graduates. This full-time equivalent number is used in computing all per student-capita observations.

b Source: Baccalaureate Sources of Ph.Ds: Rankings According to Institution of Origin, The Office of Institutional Research, Franklin and Marshall College, Lancaster, Pennsylvania, 1978.

c Source: Baron's Profiles of American Colleges, 13th Ed. (Baron's Educational Series, Inc.: New York, 1982).

d Source: Academe: The Annual Report on the Economic Status of the Profession, 1981-1982, Special Issue July-August, 1982, Vol. 68, No. 4.

e Source: Higher Education General Information Survey (HEGIS XVI), United States Department of Education, Washington, D. C., 1982.

7preference to two-stage to correct for the possibility of errors correlated across equations.[6] The 3SLS results are of generally high statistical quality. Nearly all coefficients are of the predicted sign and most variables are significant at the five-percent level. While this section discusses those results, we also present the ordinary least squares (OLS) estimates in an appendix, for the interested reader. In passing, we note that the OLS R's (0.61 for the Q equation, 0.69 for S, 0.52 for F) are very good considering the cross-sectional, per-capita nature of the data.

The results of the three-stage estimation appear in Table 2. With a few notable exceptions, the results foster a palpable notion of the baccalaureate process culminating in successful Ph.D. candidates. Inspection of our estimated output equation reveals the strong quantitative and statistical significance of faculty quality, academic and administrative support, a high faculty-student ratio, and undergraduate specialization in quality undergraduate production.

A numerical example is useful in illustrating the relative efficacy of additional expenditure on administrative, academic or faculty support. Consider a school with 1,000 full-time undergraduates, the average faculty-student ratio (implying 57 faculty members), and paying the average faculty salary ($23,446). Raising output by 10 Ph.D.'s per 100 students would require increasing either total academic expenditure by $1.19 million[7] administrative expenditure by $1.33 million; expenditure on faculty quality (holding faculty size constant) by $0.17 million; or $0.59 million necessary to raise the faculty size from 57 to 82 (holding faculty quality constant at the average faculty salary).

TABLE 2: RESULTS OF THREE-STAGE ESTIMATION

| Variable / Equation | Q | S | F |
|---|---|---|---|
| Output (Q) | | -0.80 (1.05) | |
| Student (S) | -0.05 (1.32) | | 0.02** (8.77) |
| Faculty (F) | 3.26* (2.18) | 25.64** (5.55) | |
| Tuition (T) | | 24.53** (3.61) | |
| Endowment (E) | | | 0.05** (3.82) |
| Capital (K) | 0.12 (0.44) | 2.64* (2.19) | -0.13** (3.19) |
| Academic (AC) | 8.35* (2.15) | | 0.43 (1.02) |
| Research (RE) | | | 0.01 (0.77) |
| Administration (AD) | 7.54** (3.90) | | |
| Scholarship (SCH) | | -25.82* (2.01) | |
| Loans (L) | | - 6.42 1.16 | |
| Faculty/Student Ratio (FSR) | 3.97** (3.33) | 19.04** (3.13) | -0.58** (3.29) |
| Undergraduate Specialization (USR) | 0.44** (3.70) | 1.57** (2.85) | -0.04** (2.95) |
| Sex Ratio (SEX) | 0.16** (2.60) | 0.70* (2.44) | |
| North Atlantic (NA) | | | 0.53 (1.50) |
| Great Lakes (GL) | | | 0.56* (1.95) |
| Western (W) | | | 0.54 (1.40) |
| Intercept | -88.68** (5.44) | 44.93 (0.37) | 7.20** (3.04) |
| Standard Error | 13.25 | 68.52 | 1.97 |

Notes: 1) Numbers in parentheses are t-values; 2) * denotes significance at the 0.05 level; 3) ** denotes significance at the 0.01 level.

Though less quantitatively interpretive, the positive significance of our undergraduate specialization ratio is noteworthy. Intuitively, it suggests that the quality of the undergraduate output, as we define it, declines as total expenditures devoted to undergraduate production are diluted through resource commitments to graduate or part-time programs. Considered together, the parameters in our output equation suggest a production relationship in which relatively well-paid professors with relatively small classes and good libraries combine with a well-financed administration in a largely undergraduate environment to produce Ph.D. fiber. The only surprising aspect of our output equation is the apparent insignificance of student quality as measured by median SAT score. This result may reflect the possibility that median student quality is not a good indicator of academic potential which is latent in, say, only the upper decile of the student population.

The parameters for the student quality equation indicate that better students are drawn to schools where the undergraduate ratio is high, classes are small, and the quality of faculty is high. Interestingly, a $1,000 increase in associate professor salary is predicted to raise median SAT score of the entering class by 25.6 points. The results also suggest an administrative alternative, however. The significance of the faculty-student ratio indicates that an institution can substitute faculty quantity for quality - a one percentage point increase in the faculty-student ratio raises median SAT score 7.2 points. Not surprisingly, better students also appear to be influenced by the physical amenities of the campus as measured here by the value of the capital stock.

Somewhat striking, however, is the negative significance of scholarships on student quality. Though this result would hardly have been predicted a priori, we can offer one plausible explanation. It is quite conceivable that those schools perceived by students as the most desirable can attract quality students without scholarship incentives. However, less highly regarded institutions may have to use the financial lure extensively. Even so, our negative results suggest that these lesser esteemed schools remain unsuccessful bidders. In short, perhaps even financial support can do no better than attract a mediocre student to a mediocre school when qualitative perceptions rule. Similar reasoning may be extended to account for the seemingly perverse relationship displayed by the positive relationship between student quality and tuition. If tuition is a relatively true index of institutional quality, one would expect to find better students at more expensive schools.

Recall from the discussion in Section II that the faculty equation specified in our model could be viewed as a reduced-form equation from a supply-and-demand system for faculty quality. Generally, the results support this interpretation. Observe that, from a supply perspective, quality students and the financial security of a school's endowment appear to draw quality faculty. However, from a factor demand standpoint, the resource trade-off between well paid faculty and class size is evident from the negative significance of the faculty-student ratio coefficient. For example, a one percentage point increase in faculty-student ratio is predicted to cost associate professors $579 in annual salary. Additionally, higher resource costs of graduate vis-a-vis undergraduate faculty is implied by the significant negative coefficient on undergraduate specialization ratio. Finally, the negative and significant sign on capital suggests that administrators view the quality of physical facilities as a substitute for quality faculty.

## IV. Concluding Remarks

The composite picture which emerges from our model is one emphasizing the role of human capital. This result is perhaps not surprising, originating as it does in an enterprise whose chief role is the production of human capital. But it is nonetheless striking that the role played by physical facilities, for example, seems no more than a minimally facilitating one. Rather, the significant variables in the baccalaureate preparation of Ph.D.'s are faculty salary, academic and administrative support, small classes, and a commitment to undergraduate education. Quality students and quality faculty, buttressed by academic support in the form of libraries, laboratories, and, more recently, computers, appear as the major cogs driving the educational process. The results of this study re-emphasize the critical importance of the "purely academic" in the world of higher education.

In a related vein, our results confirm the interdependencies existing in higher education. Not only do students, faculty and administrators play their respective roles in academe, they also respond to each other's successes. The implication is that the simultaneous approach employed in this study represents an appropriate methodology for evaluating educational production.

ENDNOTES

1. We recognize that one of the complications of analyzing and evaluating universities is that they produce many outputs in addition to preparing undergraduates for their livelihood. These include the non-vocational benefits of undergraduate education, graduate education, basic and applied research, adult education, extension services, and community cultural services. For this reason we limit our focus to institutions which specialize in undergraduate education, i.e., which do not have substantial doctoral programs.

2. We are in the process of collecting additional measures of alumni achievement, including the business, law, and medical professions. The present study represents a first attempt at formulating and testing a simultaneous model of the educational process for one, viable output.

3. As Summers & Wolfe have noted [1977, p. 639], "In education, all inputs cannot be selected as in a factory...Further, the production function, as used in its classical context, relates the maximum attainable level of output for given inputs to the level of inputs - it describes the boundary of the production set. There is little reason to believe that we know enough to have any confidence at all that schools are attaining such productive efficiency. In any case, it is clear that estimation procedures based upon cost-minimization assumptions are inappropriate."

4. One of the more current and comprehensive bibliographies on the subject appears in Elchanan Cohn's The Economics of Education, pp. 353-444.

5. We have also estimated the system in Cobb-Douglas form, thereby imposing unitary substitution elasticities and constant output elasticities. We present the linear results because they are simpler to interpret, because our analysis would not change substantively under either set of results, and because we find no compelling a priori justification for either functional form. Were the output equation a production function in the traditional sense, then we would prefer the Cobb-Douglas formulation. However, as we have indicated in footnote 3, this is not the case.

6. Indeed, estimates of these correlation coefficients based on the residuals from the second-stage indicate that such a problem exists. The estimated correlation between the errors of the Q and S equations is 0.61; between Q and F, -0.64; and S and F, -0.93. Following the third-stage, these correlations were estimated to be 0.42, 0.39 and -0.01, respectively.

7. This results was obtained as follows. The 8.35 coefficient implies that a $1,000 per student increase in academic expenditure would result in a long-run (55 years) increase of 8.35 Ph.D.'s per 100 students. For a school size of 1,000 this translates into a $1 million expenditure. Finally, to raise the level by 10 instead of 8.35, the required expenditure would be (10/8.35) x $1 million, or $1.2 million.

## REFERENCES

1. Astin, Alexander W., "Undergraduate Achievement and Institutional Excellence: Science (August 16, 1968), 661-668.

2. Becker, G.S., "Investment in Human Capital: A Theoretical Analysis," Journal of Political Economy 70 (Supplement: October 1962), 9-49.

3. Becker, G.S. Human Capital - A Theoretical and Empirical Analysis, with Special Reference to Education, (New York: National Bureau of Economic Research, Columbia University Press, 1964).

4. Bowles, Samuel, "Towards an Educational Production Function," in W.Lee Hansen (ed.) Education, Income, and Human Capital (New York: National Bureau of Economic Research, Columbia University Press, 1970).

5. Hause, J.C. "Earnings Profile: Ability and Schooling," Journal of Political Economy 80 (May-June 1972), 108-138.

6. Hunt, Shane, "Income Determinants for College Graduates and the Return to Educational Investments," Yale Economic Essays 3(2) (1963), 305-358.

7. McGuckin, Robert H. and Winkler, Donald R., "University Resources in the Production of Education," Review of Economics and Statistics Vol. 61 (May 1979), 242-248.

8. Solomon, Lewis C., "The Definition and Impact of College Quality," in Lewis C. Solomon and Paul J. Taubman (eds.) Does College Matter? (New York: academic Press, 1973).

9. Summers, Anita A. and Wolfe, Barbara I., "Do Schools Make A Difference?" in American Economic Review Vol. 67, No. 4 (Sept. 1977), 639-651.

10. Weisbrod, Burton A. and Karpoff, Peter, "Monetary Returns to College Education, Student Ability, and College Quality," Review of Economics and Statistics 50 (Nov. 1968), 491-510.

11. The Annual Report on the Economic Status of the Profession, 1981-1982 Special Issue, Academe Vol. 68, No. 4 (July-August, 1982).

12. Baccalaureate Sources of Ph.D.s: Rankings According to Institution of Origin, The Office of Institutional Research, Franklin and Marshall College, (Lancaster, Pennsylvania, 1978).

13. Baron's Profiles of American Colleges, 13th Ed. Baron's Educational Series, Inc. (New York, 1982).

14. Higher Education General Information Survey (HEGIS XVI) United States Department of Education (Washington, D.C., 1982).

APPENDIX A: RESULTS OF OLS ESTIMATION

| Variable \ Equation | Q | S | F |
|---|---|---|---|
| Output (Q) | | 0.81** (1.97) | |
| Student (S) | 0.03** (2.33) | | 0.01** (8.07) |
| Faculty (F) | -0.75* (1.74) | 13.80** (6.10) | |
| Tuition (T) | | 38.38** (6.67) | |
| Endowment (E) | | | 0.04** (2.93) |
| Capital (K) | -0.12 (0.55) | 2.27* (1.88) | -0.61 (1.42) |
| Academic (AC) | 12.19** (3.49) | | 0.31 (0.50) |
| Research (RE) | | | 0.03 (1.39) |
| Administration (AD) | 8.84** (4.43) | | |
| Scholarship (SCH) | | -51.53** (3.31) | |
| Loans (L) | | -13.22 (1.55) | |
| Faculty/Student Ratio (FSR) | 2.74** (2.69) | 12.69 (2.16) | -0.46** (2.54) |
| Undergraduate Specialization (USR) | 0.25** (2.97) | 0.73 (1.55) | -0.34* (2.23) |
| Sex Ratio (SEX) | 0.18** (2.98) | 0.55 (1.59) | |
| North Atlantic (NA) | | | 1.82** (3.79) |
| Great Lakes (GL) | | | 0.99* (2.10) |
| Western (W) | | | 1.54** (3.35) |
| Intercept | -53.64** (4.82) | 372.31** (5.71) | 12.63** (6.94) |
| $R^2$ | .61 | .69 | .52 |
| Standard Error | 10.96 | 62.39 | 1.87 |

Notes: 1) Numbers in partheneses are t-values; 2) * denotes significance at the 0.05 level; 3) ** denotes significance at the 0.01 level.

APPENDIX B

## College Sample: Ph.D. Alumni Per 100 Student Capita

| | | |
|---|---|---|
| Swarthmore C. | PA | 108.20 |
| Oberlin C. | OH | 94.60 |
| Reed C. | OR | 88.02 |
| Pomona College | CA | 77.04 |
| Haverford C. | PA | 73.80 |
| Wabash C. | IN | 71.06 |
| Grinnell C. | IA | 56.43 |
| C. of Wooster | OH | 52.61 |
| Carleton C. | MN | 51.62 |
| Knox C. | IL | 50.58 |
| Wellesley C. | MA | 48.91 |
| Park C. | MO | 47.82 |
| Lawrence U. | WI | 46.93 |
| Cornell C. | IA | 44.98 |
| Earlham C. | IN | 44.64 |
| Maryville C. | TN | 43.95 |
| Williams C. | MA | 43.11 |
| Occidental C. | CA | 42.94 |
| Davidson C. | NC | 42.78 |
| Depauw U. | IN | 42.73 |
| Belott C. | WI | 42.70 |
| Mount Holyoke C. | MA | 39.58 |
| Ohio Wesleyan U. | OH | 37.49 |
| Wesleyan U. | CT | 36.88 |
| Wheaton C. | IL | 36.43 |
| Franklin and Marshall C. | PA | 36.43 |
| U. of Redlands | CA | 35.34 |
| Lebanon Valley C. | PA | 34.51 |
| Muskingum C. | OH | 33.98 |
| Vassar C. | NY | 33.86 |
| Bates C. | ME | 33.08 |
| Harvey Mudd C. | CA | 32.98 |
| Hamilton C. | NY | 32.81 |
| Berea C. | KY | 32.68 |
| Goucher C. | MD | 32.29 |
| Whitman C. | WA | 32.03 |
| Smith C. | MA | 31.95 |
| Kalamazoo C. | MI | 31.61 |
| Agnes Scott C. | GA | 31.58 |
| Lafayette C. | PA | 31.57 |
| Manchester C. | IN | 31.17 |
| Union C. | NY | 30.85 |
| Hastings C. | NE | 30.78 |
| Willamette U. | OR | 30.02 |
| Heidelberg C. | OH | 29.91 |
| Southwestern at Memphis | TN | 29.88 |
| Juniata C. | PA | 29.84 |
| Spring Hill C. | AL | 29.80 |
| Ursinus C. | PA | 29.39 |
| Birmingham Sthn C. | AL | 29.30 |
| Middlebury C. | VT | 29.15 |
| Washington Jeff C. | PA | 29.07 |
| Allegheny C. | PA | 28.34 |
| Hope C. | MI | 27.15 |
| Muhlenberg C. | PA | 26.68 |
| Saint Olaf C. | MN | 26.31 |
| Trinity C. | CT | 26.23 |
| Gettysburg C. | PA | 26.22 |
| Phila C. Phar & Sci | PA | 26.19 |
| Wofford C. | SC | 26.15 |
| Denison U. | OH | 25.79 |
| Macalester C. | MN | 24.77 |
| U. of the South | TN | 24.72 |
| Colgate U. | NY | 24.65 |
| C. of the Holy Cross | MA | 24.28 |
| Goshen College | IN | 24.12 |
| Marietta C. | OH | 23.52 |
| Kenyon C. | OH | 23.25 |
| Bethany C. | WV | 23.17 |
| Ripon C. | WI | 23.08 |
| Coe C. | IA | 22.95 |
| Randolph-Macon C. | VA | 22.84 |
| Dickinson C. | PA | 22.81 |
| Washington and Lee U. | VA | 22.69 |
| Hendrix C. | AR | 22.16 |
| Albion C. | MI | 21.79 |
| Bucknell U. | PA | 20.76 |
| Beneva C. | PA | 20.67 |
| Mount Union C. | OH | 20.56 |
| Connecticut C. | CT | 20.33 |
| Augustana C. | IL | 19.92 |
| Hanover C. | IN | 19.82 |
| Colby C. | ME | 19.54 |
| Centenary C. of Louisiana | LA | 19.53 |
| Gonzaga U. | WA | 19.17 |

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|---|---|---|
| ctan C. | NY | 18.99 |
| fred U. | NY | 18.19 |
| Lake Forest U. | IL | 17.86 |
| Bridgewater C. | VA | 17.85 |
| Asbury C. | KY | 17.65 |
| Wittenberg U. | OH | 17.57 |
| Hemline U. | MN | 17.53 |
| Drury C. | MO | 17.53 |
| Luther C. | IA | 17.48 |
| Carroll C. | WI | 17.48 |
| Whittier C. | CA | 17.47 |
| Thiel C. | PA | 17.41 |
| Linfield C. | OR | 17.30 |
| Otterbein C. | OH | 16.86 |
| Georgetown C. | KY | 16.61 |
| U. of Richmond | VA | 16.40 |
| Oklahoma Bapt U. | OK | 16.39 |
| Springfield C. | MA | 16.36 |
| Calvin C. | MI | 16.35 |
| Saint John's U. | MN | 16.03 |
| Westminster C. | PA | 15.40 |
| Saint Lawrence U. | NY | 14.98 |
| Trinity C. | DC | 14.76 |
| Western Maryland C. | MD | 14.75 |
| Furman U. | SC | 14.41 |
| Alma C. | MI | 14.40 |
| Albright C. | PA | 14.37 |
| Butler U. | IN | 14.33 |
| Worcester Poly Insti. | MA | 14.17 |
| Hardin-Simmons U. | TX | 14.10 |
| Millikin U. | IL | 13.67 |
| Central U. of Iowa | IA | 13.23 |
| Upsala C. | NJ | 13.00 |
| Baldwin-Wallace C. | OH | 12.94 |
| Drew U. | NJ | 12.91 |
| Saint Joseph's U. | PA | 12.83 |
| Wake Forest U. | NC | 12.64 |
| Gustavus Adolphus C. | MN | 12.51 |
| Canisius C. | NY | 12.20 |
| Saint Bonaventure U. | NY | 11.93 |
| Valparaiso U. | IN | 11.88 |
| Le Moyne C. | NY | 11.82 |
| Capital U. | OH | 11.79 |
| Augustana C. | SD | 11.50 |
| Providence C. | RI | 10.85 |
| Saint Peters C. | NJ | 10.73 |
| Stetson U. | FL | 10.52 |
| Taylor U. | IN | 10.38 |
| U. of Scranton | PA | 10.34 |
| West VA Wesleyan C. | WV | 10.01 |
| American Intrnatl C. | MA | 10.00 |
| John Carroll U. | OH | 9.77 |
| Saint Norbert C. | WI | 9.47 |
| C. of New Rochelle | NY | 9.37 |
| Drake U. | IA | 9.24 |
| U. of Puget Sound | WA | 9.21 |
| La Salle C. | PA | 8.68 |
| Oklahoma City U. | OK | 8.56 |
| Lewis and Clark C. | OR | 8.34 |
| Clarkson C. of Techn | NY | 8.18 |
| Trinity U. | TX | 8.09 |
| Saint Francis C. | NY | 8.05 |
| Bradley U. | IL | 8.03 |
| Drexel U. | PA | 7.75 |
| Seattle Pacific U. | WA | 7.59 |
| Mercer U Main Campus | GA | 7.39 |
| U. of Dayton | OH | 7.20 |
| Ohio Northern U. | OH | 7.02 |
| Pacific Luth U. | WA | 6.97 |
| U. of San Francisco | CA | 6.73 |
| Saint Mary's U. San Antonio | TX | 6.72 |
| Seattle U. | WA | 6.56 |
| U. of Portland | OR | 6.52 |
| Elmhurst C. | IL | 6.46 |
| Villanova U. | PA | 6.35 |
| Siena C. | NY | 6.30 |
| Loyola C. | MD | 6.25 |
| Saint Mary's C. | CA | 6.13 |
| Concordia C. at Moorhead | MN | 6.06 |
| Simmons C. | MA | 5.60 |
| Fairfield U. | CT | 5.29 |
| Tuskegee Institute | AL | 5.09 |
| Niagara U. | NY | 4.93 |
| Iona C. | NY | 4.90 |
| De Paul U. | IL | 4.75 |
| U. of the Pacific | CA | 4.62 |
| Loyola Marymount U. | CA | 3.73 |
| Pepperdine U. | CA | 3.11 |